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# Environmental Assessment of the Gulf Crisis

## Report of the Secretary-General of the Conference

INDEX

| | | Page |
|---|---|---|
| I. | Introduction | 2 |
| II. | Oil Pollution Emergency in the Persian Gulf | 3 |
| III. | Environmental Consequences of the Armed Conflict between Iraq and Kuwait | 7 |

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## I. INTRODUCTION

1. At its second session, the Preparatory Committee in its decision 2/18, paragraph 2, invited the International Maritime Organization and the United Nations Environment Programme to continue their efforts to assess and counter the possible long-term environmental effects on the region and the world at large, and requested the Secretary-General of the United Nations Conference on Environment and Development to follow the matter closely with the interested organizations and report to the Preparatory Committee at its third session.

2. In response, IMO and UNEP prepared the following reports which were presented in their respective governing councils, 3 June 1991 and 20-31 May 1991.

## II. OIL POLLUTION EMERGENCY IN THE PERSIAN GULF

Note by the IMO Secretariat

INTRODUCTION

1. One of the fundamental components of IMO's strategy for the protection of the marine environment is to strengthen the capacity for national, regional and global action to prevent, control, combat and mitigate marine pollution and to promote technical cooperation to this end. In furtherance of this objective, the International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC Convention) was adopted by the diplomatic Conference on International Co-operation on Oil Pollution Preparedness and Response held in IMO Headquarters in London from 19 to 30 November 1990.

2. The primary purpose of the OPRC Convention is to facilitate international cooperation and mutual assistance in preparing for and responding to a major oil pollution incident. Although the OPRC/Convention has not yet entered into force, the Conference urged all States, pending entry into force, to cooperate among themselves and with IMO in facilitating prompt assistance in the event of a major oil pollution incident. In addition, the Conference called on the Secretary-General of IMO to initiate early implementation of the institutional arrangements outlined in the OPRC Convention, which require a pro-active role for the IMO Secretariat in providing information services, education and training, technical services, and technical assistance.

OIL POLLUTION EMERGENCY

3. In late January 1991, the world became aware of massive releases of crude oil into the Persian Gulf. It was apparent that the spill was one of the largest ever and posed a serious threat to the marine and coastal resources of the region and was certainly an oil pollution incident of the "severity" envisaged in article 7 of the OPRC Convention justifying a request for assistance. In addition, it was clear that no one Government would be able to handle the enormous clean-up efforts required and that international cooperation and assistance would be necessary.

4. Almost immediately, a number of Governments made it known to IMO that they would be ready to render assistance in dealing with the incident; and it became clear that IMO could, if requested, commence channelling such offers to Governments of the region as envisaged by the recently adopted OPRC Convention.

5. Upon being informed of this situation, the Government of Saudi Arabia invited IMO to screen offers of international assistance on its behalf and to ascertain the terms and conditions attached to such offers. Several other Governments of the region also requested IMO to initiate international action to combat the spillage.

6. IMO responded by establishing a Co-ordination Centre within the Marine Environment Division. For an initial period of several weeks, the Governments of France, Japan, the United Kingdom and the United States made personnel

available on a temporary basis to staff the Centre which was operating on a seven-day a week basis. Shell International provided computer experts to develop a software programme for drawing up inventories of materials, equipment and expertise being offered.

7. The main impact of the spill has been on Saudi Arabia's marine and coastal environment for which national response efforts have been coordinated through the Meteorological Environmental Protection Administration (MEPA) Operations Centre in Dhahran. MEPA has been assisted in its efforts by an International Interagency Assessment Team (IIAT), initially led by personnel from the United States Coast Guard with staff from the United States Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA), which has continuously drawn together information on the movement and extent of the oil spills, together with details of the ongoing efforts to combat the pollution and has recommended spill response strategies. IMO has been enormously assisted by the daily situation reports issued by the IIAT, together with overflight information showing the extent of offshore and shoreline oil impact and predictions of oil movement.

8. In order to facilitate the flow of information between IMO and IIAT, an IMO Liaison Officer was established in the Operations Centre in Dhahran on the basis of staff secondments by the Governments of Denmark and the United States.

9. With respect to assistance rendered to other countries of the region, IMO's efforts in this regard have been concentrated on strengthening the Regional Organization for the Protection of the Marine Environment (ROPME) and in particular the Marine Emergencies Mutual Aid Centre (MEMAC) based in Bahrain, these institutions having been established following adoption of the Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution (1978). IMO assisted in strengthening the role of ROPME during the emergency through the establishment of an IMO liaison officer, seconded by the Canadian Coast Guard, at ROPME's provisional office in Bahrain.

10. Some 17 Governments offered assistance through IMO and a number of these offers were taken up by Governments of the region. In addition, several countries have assisted countries of the region with the protection of coastal installations and clean-up efforts on a bilateral basis. International support for the clean-up effort should therefore be seen as a combination of all these initiatives.

11. At the request of several IMO Members, the Secretary-General established on 15 March 1991 a special international trust fund for the support of efforts to clean up the oil spill and mitigate its environmental impact. The primary purpose of the IMO Persian Gulf Oil Pollution Disaster Fund is to facilitate the rapid deployment of equipment and services in order to catalyse efforts to combat the oil pollution disaster and to mitigate its environmental impact and to provide a framework which will enable Governments to support the international effort under the auspices of IMO. Contributions to the Fund may be made in cash or in kind either without limitation to a specific activity or project, or for the purpose of co-financing a specific project or for a specific purpose. (See Circular letters No. 1492 and No. 1496.)

12. To date, the Governments of the United Kingdom, Japan, and Canada have contributed 1 million pounds sterling, 1.5 million US dollars, and 250,000 Canadian dollars, respectively. The Government of Luxembourg has committed 40 million Luxembourg francs in oil spill clean-up equipment and services. Pledges of contributions have been received from the Government of the Netherlands (1.25 million guilders) and the Government of Switzerland (250,000 Swiss francs). The Commission of the European Communities has indicated it will contribute 1 million ECU.

13. Since the establishment of the Fund, IMO has carried out several projects for oil clean up in environmentally sensitive areas. The projects were identified by IMO's on-scene project coordinator in close consultation with the Government of Saudi Arabia and its Planning Committee for clean-up strategies and the members of IIAT.

14. IMO-contracted projects included: the cleaning of oiled shorelines of Karan Island - an important breeding location for endangered species of turtles and migrating birds; upgrading containment boom protection at one of the few remaining undamaged salt water marshes at Saffaniyah Bay; flushing of oil from the mangroves and natural water inlets on Gurmah Island; and the provision of protective booming for two unoiled salt water marshes in Musharrabah Bay. Additional projects are also being identified for immediate implementation.

15. On the remote location of Karan Island, IMO Contractors removed over 14,000 cubic metres of oil and tarmac from shoreline areas to allow turtles pollution-free access to nesting sites. Clean sand was used to re-establish the original contour of the beach.

16. On Gurmah Island, IMO Contractors flushed free-floating oil from heavily impacted areas of mangroves and tidal channels covering the southern portion of the Island. The oil was flushed to open water where it was skimmed and collected for disposal. Containment boom was also installed to prevent re-oiling of the flushed areas.

17. In Saffaniyah Bay and Musharrabah Bay, IMO Contractors installed oil-containment booms donated by the Governments of Germany and Luxembourg to protect the few remaining areas of unoiled salt-marsh. The resources in these unoiled salt-marsh areas will be utilized for the future re-establishment of other heavily contaminated salt-marshes.

18. Work by the IMO contractors is closely monitored by IMO's on-scene project coordinator to ensure that the projects are carried out effectively and the funds provided through IMO are employed efficiently.

19. The IIAT, now headed by IMO's project co-ordinator, is continuing to identify projects at environmentally sensitive sites which may be financed by the IMO Persian Gulf Oil Pollution Disaster Fund, and further projects will be undertaken after consultation with MEPA and ROPME.

CONCLUSIONS

20. In view of the very particular circumstances of this oil spill it would not be wise to draw too many conclusions and make recommendations on how to deal with oil pollution disasters in the future. However a spill of this magnitude in the best of circumstances would severely challenge the best prepared country or indeed region. This was why the OPRC Convention was adopted by 90 States. The rapid response by Governments worldwide and the supporting role of IMO acting in co-operation with the countries affected, UNEP and other relevant organizations has demonstrated the efficacy of the OPRC Convention and the concept of the appropriate United Nations agency taking the lead in responding to an environmental emergency where possible and appropriate.

## III. ENVIRONMENTAL CONSEQUENCES OF THE ARMED CONFLICT BETWEEN IRAQ AND KUWAIT

### Report by UNEP Executive Director

### INTRODUCTION

1. At the second special session of the UNEP Governing Council, held from 1-3 August 1990, the Council expressed "its concern over the invasion of Kuwait by Iraq and the resulting destruction of the environment and disruption of social and economic structures".

### UNEP INITIATIVES

2. As his own personal concern over the actual and potential environmental effects of the military actions deepened and news of serious oil spills became known, the Executive Director consulted with his colleague, W.A. O'Neil, Secretary-General of the International Maritime Organization (IMO) on 28 January 1991 on urgent joint actions.

3. To set this process of inter-agency cooperation in motion, the Executive Director contacted all Governments concerned with the Iraq/Kuwait conflict, as well as the other United Nations agencies and appropriate international organizations. This applied particularly to IMO, which had already initiated actions to assist its Member States in their response to the massive oil spills in the waters bordering Kuwait and Saudi Arabia. The United Nations agencies and organizations in Geneva, while the executive Director of UNEP remained in contact with the Governments concerned.

#### First United Nations Inter-Agency Consultation

4. Accordingly, from 5-6 February 1991, the first United Nations inter-agency consultation was convened in Geneva to intensify cooperation and coordination within the United Nations system and optimize the diverse capabilities within it to enable it to respond rapidly to urgent requests from all members.

5. The need was recognized for a comprehensive and coordinating approach to the potential local and regional ecological, human health, and other social and economic consequences for the terrestrial, coastal and marine environments, as well as to the atmospheric effects.

6. The urgent need was also expressed for support of the Kuwait Action Plan of 1978 (a UNEP regional seas programme) through the revitalization of the Regional Organization for the Protection of the Marine Environment (ROPME) and the Marine Emergency Mutual Aid Centre (MEMAC) located in Bahrain. UNEP was recognized as having the lead role in the revitalization of ROMPE - an organization enjoying the formal support of all eight States in the region and cooperating actively with United Nations agencies - and UNEP was requested to develop a framework of action for the region.

Expert mission to region

7. At the same time, the Executive Director sent a three-person expert mission to the region to make a preliminary impact assessment of the environmental situation in the conflict area, paying particular attention to the environmental problems posed by oil slicks, and to establish an effective structure for a continued flow of objective environmental information.

8. The environmental situation in the region is now being monitored by UNEP through its GEMS/GRID facility in Geneva and by IMO. IMO had already established a round-the-clock coordinating centre in London and had set up a similar centre in Bahrain. The World Conservation Union (IUCN) had also sent an observer to the region and is coordinating ecological information in conjunction with the World-Wide Fund for Nature (WWF).

9. UNESCO and its IOC has also collected data and consulted several specialists from its roster of experts in regard to the biological and chemical effects in the region, the physical oceanography and dispersion, and the use of clean-up techniques.

Support for ROPME

10. In early February, UNEP also dispatched a senior staff member to Bahrain to help in the revitalization of the Regional Organization for the Protection of the Marine Environment (ROPME) and to assist ROPME in the implementation of its role in coordinating the activities of United Nations agencies, other organizations, and representatives of Governments providing assistance. The staff member remained in Bahrain until he recently joined the United Nations mission to Kuwait, where he and one other senior UNEP expert participated specifically in the assessment of environmental damage caused by the conflict in that country.

11. Additionally, on 22 February 1991, the Executive Director sent the Director of UNEP's Oceans and Coastal Areas Programme to UNEP's Regional Office for West Asia in Bahrain to help strengthen its ability to provide assistance to the region in the environment field and to present to the ROPME meeting a framework of action developed by UNEP. This framework received unanimous support from the ROPME meeting.

12. During this meeting, the Secretariat of ROPME presented a proposal for joint action to combat the oil spill in the region. The principal components of the proposal include surveillance, modeling, identification of sensitive areas, updating the inventory of personnel and equipment available for combating, containment, and removal of oil.

UNEP Action Plan and the Second United Nations Inter-Agency Consultation

13. Following the approval at the ROMPE meeting of the UNEP framework of action, UNEP developed a draft action plan for the mitigation, elimination, rehabilitation and protection of the environment in the Kuwait Action Plan region. This draft action plan was presented to a second United Nations inter-agency consultation in Geneva on 15 March. The draft plan or action, based on the approved framework of action, was discussed, and approved. It

envisaged placement of a Task Team core group in Kuwait by the middle of April and the completion of at least high priority surveys, assessments, and action plan designs within 90 days thereof.

14. The focus of the action plan is on four separate but interlinked areas: the coastal and marine environment, the atmosphere, inland terrestrial areas, and hazardous wastes. Of crucial importance to the success of the action is the establishment of a multi-disciplinary data-base, to be located - circumstances permitting - in Kuwait.

15. The activities proposed under the UNEP action plan are to be carried out in concert with other United Nations agencies and Organizations, the Governments of the region, and other Governments providing assistance. Every effort will be made to build up on data and information already generated by teams currently operating the area.

Trust Fund

16. An estimated budget of between $US 3.0 million and $US 3.5 million will be required for the calculated number of person-months, equipment, etc, required. These moneys are expected to come from a special UNEP trust fund set up for this purpose. Coinciding with both the second Geneva United Nations inter-agency consultation and the informal ministerial consultation held in Nairobi from 11-13 March, the Executive Director of UNEP established a Special Trust Fund devoted exclusively to the financing of the United Nations inter-agency action plan (excepting activities by IMO, which are funded by a special IMO trust fund). A significant initial contribution for $US 1.11 million was received from Japan, while a number of other States indicated that they, too, would contribute, either in cash or in kind, i.e. seconded experts, equipment, or data gathered by teams already operational in the region. Such timely action will be appreciated and recognized by the Governments of the region and will qualify the United Nations system to play an effective role in making the Governments of the region contribute substantially at a later stage in financing the detailed plan of action covering mitigation, elimination, rehabilitation and environmental protection of the area.

Funding for the implementation of the Plan

17. Funding needed for UNEP's coordinating function, in addition to support by the ROMPE States, would have to be mobilized from donor countries and non-governmental and private institutions. This would be in addition to the Fund established by the Secretary-General of IMO for the special purpose of coordinating the cleaning activities of the oil spills. ROMPE support will be indicated by the Organizations' Council meeting tentatively scheduled for the end of June.

18. There is a need and possibility for an innovative global fund-raising mechanism, initially only for the environmental rehabilitation in this particular area, but subsequently for universal application in case of other environmental emergencies. The Executive Director of UNEP has initiated consultations with the parties concerned with a view to developing a proposal to this effect.

LEGAL ASPECTS

19. Environmental disruption is an inevitable concomitant of war. In many instances, this combat-associated disruption of the environment is an incidental outcome of hostile military actions. In other instances, it is an intentional component of a belligerent's strategy. The salient legal constraints on environmental disruption in time of war are summarized here, especially those that might apply to the Iraq/Kuwait conflict, together with and indication of their level of formal acceptance.

(a) The Hague Conventions II of 1899 and IV of 1907 on the Laws and Customs of War on Land

20. Both of these treaties commit their Parties - when in the role of occupying State - to safeguard the public buildings, real property, forests, and agricultural works of the occupied State, administering them according to the rules of usufruct. To date, approximately 31 percent of all nations are Parties to one or both of these treaties (including four of the five permanent members of the United Nations Security Council), although not Iraq.

(b) Berne Protocol I of 1977 (additional to the Geneva Conventions of 1949) on the Protection of Victims of International Armed Conflicts

21. This treaty commits its Parties to take care in warfare to protect the natural environment against widespread, long-lasting, and severe damage. Prohibited, therefore, are methods or means of warfare that are intended, or may be expected, to destroy, remove, or render useless - for any motive - objects indispensable to installations, foodstuffs, crops, livestock, agricultural areas, and irrigation works. The Parties also agreed not to attack dams, dikes, and nuclear electrical generating stations, if such attack may cause the release of dangerous forces and consequent severe losses among the civilian population. To date, approximately 57 percent of all nations are Parties to this treaty (including two of the five permanent members of the United Nations Security Council), although not Iraq.

(c) World Cultural and Natural Heritage Convention of 1972

22. The parties to this treaty recognize that certain cultural and natural heritage sites and monuments are of outstanding universal value and constitute an worldwide heritage whose protection is the duty of the international community as a whole. The parties undertake not to take any deliberate measures that might damage, directly or indirectly, any cultural or natural heritage situated on the territory of other Parties. To date, approximately 67 percent of all nations are Parties to this treaty (including all five permanent members of the United Nations Security Council), and including Iraq, which at present has registered one such historic monument.

(d) Geneva Protocol of 1925 on Chemical and Bacteriological Warfare

23. The parties to this treaty accept a prohibition of the use in war of all chemical agents, and also of the use of bacteriological methods of warfare.

To date, approximately 32 percent of all nations are parties to this treaty including three of the five permanent members of the United Nations Security Council), although not Iraq.

(e) Environmental Modification Convention of 1977

24. The parties to this treaty undertake not to engage in military or any other hostile use of environmental modification techniques (i.e., deliberate manipulations of natural processes) having widespread, long-lasting, or severe effects as the means of destruction, damage, or injury to the other Parties. To date, approximately 32 percent of all nations are Parties to this treaty (including three of the five permanent members of the United Nations Security council), although not Iraq.

(f) Proposed action by the Governing Council of UNEP

25. It is obvious that all these treaties need to be thoroughly reviewed particularly (e). The Governing Council may wish to recommend to the General Assembly that it review this treaty and consider strengthening it.

INFORMAL MINISTERIAL CONSULTATION

26. At the informal Ministerial Consultation held in Nairobi from 11-13 March 1991, the Executive Director invited discussion on environmental aspects of the Iraq/Kuwait conflict. Profound appreciation was voiced by the participants for the UNEP initiatives. They suggested that UNEP should play a principal role in the coordination of the activities related to the mitigation of the environmental damage caused by the conflict. There was also general support for the idea of a United Nations system for dealing with environmental emergencies and UNEP was encouraged to set up an international register of suitable experts and equipment required in cases of environmental emergencies, as well as a register of areas of ecological risk. UNEP was also urged to ensure the inclusion in any post-war arrangements of both the environmental and economic aspects of hostilities.

27. Furthermore, it was emphasized that transboundary effects of the conflict should be addressed, while existing legal instruments pertaining to the use of the environment in war be closely examined. It was also proposed UNEP should have the flexibility to respond in future cases of environmental emergencies, for instance through larger fund programmes rather than being forced to establish a special trust fund. The need for the capability to anticipate and avoid environmental problems was strongly underscored.

THE IRAQ/KUWAIT CONFLICT - THE ENVIRONMENTAL CONSEQUENCES

28. A special UNEP mission visited Saudi Arabia from 4-14 February 1991, at the time of the major oil slick off the east coast of that country. In March, two UNEP staff participated in a United Nations mission to Kuwait. UNEP's role in this mission was to carry out a first rapid reconnaissance survey of the post- conflict environmental situation in Kuwait. The UNEP team was visited, or carried out survey flights over, most of the country. The

following report is based primarily on the findings of these missions, supplemented by other reliable information that had subsequently become available by 24 April.

Oil fires

29. The burning of the oil wells in Kuwait is the most widely known and obvious consequence of the Iraq/Kuwait conflict. Estimates of the number of wells that were burning vary from 500 to 650. The UNEP mission felt, however, that this might be an underestimate and that perhaps 700 or more wells were alight when the oil field fires were at their maximum. Oil industry experts considered that at the period of maximum conflagration, four to six million barrels of crude oil were being consumed daily - roughly twice the normal daily production. This figure is likely to have been greatly reduced by now.

30. Since initial ignition, the oil field fire situation has been gradually changing. Many wells are, unaided, diminishing their burn rate or are extinguishing themselves due to natural induction of ground water in a process known as "coning". At the time of the mission's departure it was estimated that some 40-50 well fires had gone and that many more were in the process of going out.

31. This natural extinguishing process posed a new environmental problem that came into prominence during the course of the mission. Wells no longer burning continued to gush onto the land large quantities of oil that converged to form large oil lakes. At one time torrents of oil overran the land - soil erosion was seen by the mission - and it seemed that this surface oil would make its way down natural drainage lines to the sea, thus posing a new threat to the marine environment. In an effort to curtail this oil flow, attempts were made to relight some of the wells that were no longer burning. This had limited success and, to the mission's knowledge, only six wells were actually reignited. The surface oil flow was finally controlled by containment through construction of earth dams and berms. It will not finally be overcome until the flow of all the gushing wells is stopped through capping. At the moment, capping is proceeding at an estimated rate of 8-10 wells per week.

32. Emissions from the burning wells take two forms: the visible soot and particulates and the invisible gases. Each oil field has its own smoke plume (as does each wellhead fire), which is directed by the lower level winds and so act as weathervanes about the oil field according to wind direction. The plumes gradually rise through the lower atmosphere until, in general, they reach an upper surface at about 18,000m. and lower surface at about 1,000 m. At a 1,000 km. distance, the plume width, judging from satellite images can be several hundred kilometres wide. At present, the plumes do not seem to be rising to more than 4,500-5,000 m, though there are almost certain to be local emission spikes rising above this level. Wind directions at different levels above the ground may at times cause different elements of the plumes to move in different directions in a complex pattern.

33. Oil smoke is particularly efficient at absorbing solar radiation, so that in the centre of areas covered by the plumes, there is little or no light and air temperature can be depressed by 10°C or more. The weathervane effect, however, means that the same area of ground or water is not covered by the

plumes for very long. At the moment, emissions do not seem to have reached upper atmospheric levels, so any cooling effects are likely to be local, or perhaps regional, but not global, in extent. There is also constant fall-out of particles along the length of the plumes, so that only the smallest particles remain at the extreme limits of the plumes.

34. There are still few good measurements of the contaminant content of the air in the oil fields and in surrounding regions affected by the smoke plumes. Those that have been made suggest that there has been a slight increase in levels of sulphur compounds, carbon monoxide and total hydrocarbons, bringing them to about the same levels as those found in Kuwait before the fires started. Kuwait at that time, however, had an active oil processing industry, other commercial activities and many cars-a situation that differs from that of today. The southern oil fields, particularly Wafra, differ from the others in that they are known to be producers of hydrogen sulphide and sulphur dioxide and it is likely that the main releases of these substances will come from the southern fields. As yet there are no available ground measurements from the southern area.

35. There are insufficient data to be able to state with any certainty the probable effects of exposure to these smoke plumes on human and ecosystem health. At the moment, knowledge is limited to a few measurements taken in the field, data from some fixed ground stations in Kuwait City, and data taken in the smoke plumes by a research aircraft. The latter recorded sulphur dioxide levels of 1,000 ppb. in part of the plumes 100 km downwind of the source. Such levels could cause problems for asthmatics or those with other respiratory problems if the plumes were wafted to the ground; most healthy people could endure such exposure without damage to health. Although there may be acidic rainstorms, these are unlikely to pose a long-term problem to the soils and waters of the region, which would require repeated exposure to acidic deposition before they became significantly affected.

36. Frequently repeated good air contamination measurements at ground level in a number of locations, as well above ground within the plumes, remain essential and must be given the highest priority.

Oil in the sea

37. Shortly after 22 January 1991, there was a massive release of crude oil into the sea from the Kuwait Oil Company Sea Island terminal off Al-Ahmadi and from three oil tankers anchored off the North Pier. Together, these releases amounted to some 10 million barrels of crude oil. Further release of oil was prevented by the bombing of the Al-Ahmadi tank farm loading manifolds, the Sea Island terminal and one of the tankers.

38. A USA National Oceanic and Atmospheric Administration (NOAA) satellite image taken on 25 January shows a smoke plume from the damaged Sea Island terminal and the oil slick, by this time some 50 km. long and 8 km. wide. Assuming an average thickness of 0.5 cm. for the slick, its total volume could have been about 13 million barrels - more than enough to contain the 10 million barrels thought to have been released. As this slick moved down

the Kuwait coast toward Saudi Arabia, it rapidly lost much of its volume by evaporation and by extensive dispersal in the form of sheen - a fine surface film of oil.

39. On 24 January, this slick was reportedly observed entering Saudi Arabian territorial waters in the region of Khafji (28'25'N). South of the Saudi Arabian-Kuwait border, it was augmented by oil from the loading terminal and other installations damaged during military operations at khafji at the end of January and the beginning of February. ARAMCO estimates put the Khafji oil release at between 100,000 and 500,000 barrels.

40. On 7 February, the UNEP mission overflew the oil slick off the coast of Saudi Arabia and estimated its total volume as being about 1 million barrels. The slick was then 120-130 km long and 5-25 km wide, broken into several patches and bands. By 11 February, the slick extended along the coast of Saudi Arabia from 28'15'N (just to the north of Mishab) to Abu Ali island (27'20'N). A fortunate combination of winds and currents have kept this slick more or less stationary within these limits so that very little oil has moved beyond Abu Ali island towards the southern parts of Saudi Arabia and other countries to the south. The affected coast of Saudi Arabia has, however, been severely impacted, although sufficient steps were taken to prevent damage to important desalination and industrial plants. So far, some 400,000 barrels of crude oil have been recovered from this slick.

41. At the time of the UNEP mission (February 1991), it was not possible to overfly Kuwait waters for security reasons, so it remained conjectural as to whether there were further oil slicks in the region. Subsequent surveys, including those of the UNEP team, which was part of the United Nations mission as of 2 April, failed to find any extensive oil slicks, although there were patches of sheen.

42. The aerial survey of the coast of Kuwait and its off-shore waters (20 and 22 March 1991) showed no indication of massive fouling of beaches by oil. In only a few scattered sites along the coast were oil traces and deposits found. Some 10,000 barrels of oil were in the commercial harbour at Shuaiba; this had resulted from a separate secondary release from Shuaiba harbour off-loading facilities, including a waste oil storage tank, that took place in late February. Patches of sheen were noted along the coast where winds and currents had driven them against peninsulars.

43. The mission, however, did find that there was an extensive film of particulates on the water surface, which formed into bands and whorls very like an oil slick. These particles almost certainly came from the smoke plumes from the oil well fires. Their impacts on coastal and marine ecosystems are not known. It was noted, however, that one tide could cover a beach with black particulates that the next tide would remove, leaving the beach clean. It is possible that these particulate patches - which are extensive - are being mistaken for oil slicks.

Land degradation

44. The conflict in Kuwait led to three main types of land degradation:

(a) Defensive constructions such as hardened gun emplacements, hardened personnel shelters, tank and mortar revetments, dug-in ammunition dumps, fuel bowser pits and a wide variety of fences, trenches and shelters. Trenches filled with oil to be lit during battle were a special feature of the Kuwait conflict;

(b) Off-the-road vehicle movement results in tracks that break up both the vegetation cover and the upper soil layers, which can lead to erosion by wind and water where such damage has been severe; there will almost certainly be an increase in the amount of wind-blown material contributing to an increase in the severity of sandstorms during the season in which they are prevalent. In some cases, however, especially on gentle gradients, such tracks can result in better rainwater penetration within them and so to subsequent improved plant growth;

(c) Explosion damage from bombs, missiles and shells result in craters. Bomb and shell craters tend to occur in localized groups. In each crater the vegetation is removed and the upper soil layers removed or rearranged. In some cases, however, such craters fill with water, become centres of habitat diversity, and act as small wildlife refuges. Craters with water, algae and increased plant growth were seen.

45. The country was surveyed, mainly by air, to determine the severity of impact resulting from these three types of land damage.

46. Much of the coast has been very severely damaged by these causes, though there are areas, particularly in the north, where such effects are slight to moderate. In general, the south and the north have been affected most, the south by defensive constructions, the north by off-the-road tracks resulting from armoured vehicle movement and battles. The extreme west and southwest of the country and Bubiyan Island in the northeast have hardly been affected by this sort of damage.

Unexploded ordnance

47. Mines and other unexploded ordnance pose one of the most serious and potentially long-lasting threats to the environment of Kuwait. Vast minefields were laid along all the coasts and in broad bands across the south of the country. Ports and harbours are faced with extensive sea minefields. In addition to the minefields, unexploded ordnance is widespread, being scattered around every site where there was conflict, even if only a few armoured vehicles were involved. With few exceptions, these conflict sites are unmapped. At the time of the mission, two to five people were admitted daily to Kuwait City hospitals with explosion injuries - mainly to arms and legs. During the mission, the military unexploded ordnance clearance operation within Kuwait celebrated the removal of the 3,000,000th explosive item.

48. Mine clearance operations are not always totally successful and a danger from missed items always remains. In Kuwait this will be most serious in the coastal zones, which form the main recreational areas for the people.

49. It may not be possible to clear the huge minefields in the south, large areas of which may have to be securely fenced and left. If this is done, it will be essential to leave really safe passages through these minefields, made at intervals to allow nomadic peoples and their livestock to move seasonally.

Agriculture and fisheries

50. Agriculture and fisheries were important but small parts of the economy of Kuwait. At the time of the mission, both were at an almost complete standstill. The vital irrigation system was not functioning, so that even perennial crops were threatened and might not survive the coming summer without irrigation water. The majority of livestock perished, and those that did survive are being hard hit by the consequences of the oil fires and consequently may not survive. Fishing activities have almost ceased because fishing boats and fisheries equipment were either destroyed or taken away. Marine minefields effectively prevent fishing at present.

Infrastructure

51. The environment and environment-related infrastructure of Kuwait ceased to function, and in may areas, disappeared. Equipment, large and small, was destroyed or taken away. It will take some time before any environment-related sector will regain the importance it had before the conflict. Restoration of these services and facilities must be a priority for Kuwait because of the nature of the oil industry upon which it depends and the potential of that industry for impacts on the environment.

MAIN CONCLUSIONS AND RECOMMENDATIONS

52. Although an objective and accurate assessment by UNEP of the environmental problems resulting from the hostilities is to this day seriously hampered by restrictions on free access to many parts of the sea area and the as yet classified nature of some relevant information gathered by the military, it is recommended:

- To further enhance cooperation, greater involvement and utilization of skills and resources of both the United Nations agencies and organizations and Governments willing and able to provide expertise and resources;

- To further revitalize the Regional Organization for the Protection of the Marine Environment (ROPME), an organization comprised of the States around the sea, and strengthen its secretariat to deal with the war-related regional environmental problems;

- To carry out immediate surveys of the conflict area to identify all smoke emission sources, categorizing them by type and expected burn duration, if left, as well as to carry out ecological surveys of the conflict zone as soon as possible in order to ascertain the extent of

the ecological damage caused. This should include specialized ground and air surveys of the coastal area of the region, paying particular attention to those areas affected by amphibious landings. Based on these surveys, appropriate remedial activities and programmes should be designed and put in place over the following two to three years. These should involve the establishment of a specialized database;

- That national environmental monitoring and assessment centres should be set up in each country to ensure that environmental and resource data are fed into the planning and decision-making processes of each Government concerned;

- That, as soon as the situation permits, there should be an immediate survey of all known nuclear, biological and chemical warfare manufacturing production centres in the area to ensure that there has been no contamination of adjacent and other areas;

- To maintain close liaison with the military of the conflict participants to locate and demarcate all mine fields, including those at sea, for the subsequent clearance of these areas. The initial survey should be completed within six months, the clearance operations within three years;

- That information be obtained, now scattered and some of it inaccessible, about the risk from release of hazardous chemicals from damaged industrial plants.

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